MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2022/2023

ERT3036 – ADVANCED ROBOTICS

(RE)

6 JULY 2023
2.30 p.m. - 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 5 pages including the cover page with 4 Questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1 (25 marks)

(a) Wheeled mobile robots (WMRs) can be classified in terms of the total degrees of movement d and its steerability s. Give 3 examples of WMRs with types $(d,s) = (1,1)$, (2,0) and (3,0). [6 marks]

(b) Consider the diagram in Figure 1. Apply Dijkstra's algorithm to find the shortest path from point A to point F. Show your working steps. List the vertices in the order which you have visited them. [19 marks]

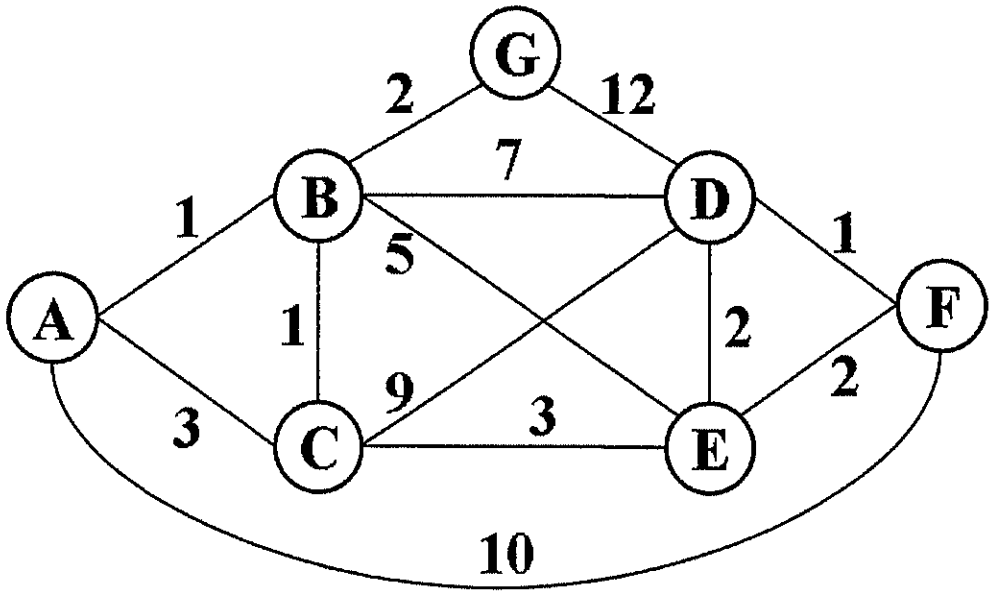

Figure 1.

Continued...

Question 2 (25 marks)

(a)

(i) Give 5 advantages of a *biped* robot, as compared to a wheeled mobile robot. [5 marks]

(ii) Briefly discuss what is *Static Stability*. How many legs are needed to ensure statically stable walking? [5 marks]

(b) Given a 2-link biped robot as shown in Figure 2. The center of mass (CoM) for each link is at the center of the link. The moments of inertia are I_1 and I_2, respectively.

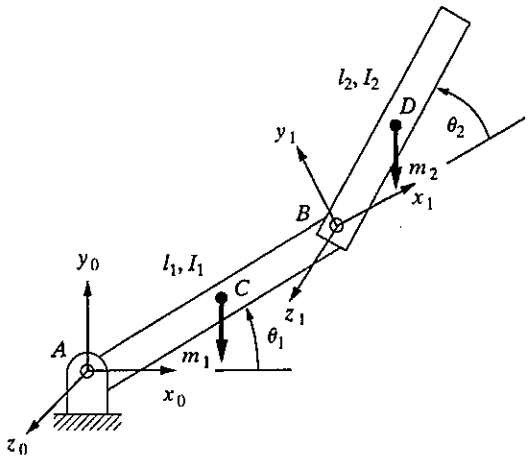

Figure 2.

(i) Find the total velocity of CoM for link 2. [6 marks]

(ii) Find the total kinetic energy of the system, K. [9 marks]

Continued...

Question 3 (25 marks)

(a)

(i) What are the advantages of a Quadrotor over Fixed Wing? [5 marks]

(ii) A LiPo (Lithium Polymer) batteries are primarily used in drones and other radio-controlled devices. Briefly discuss how to prolong the lifespan of LiPo batteries. [6 marks]

(b) Figure 3 depicts one of the common aerodynamic layout of quadrotor. Briefly discuss the advantages of this design. [4 marks]

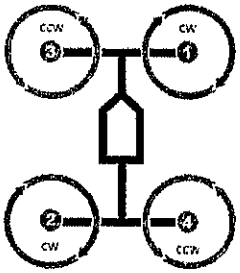

Figure 3.

(c) The weight estimation of a quadrotor's basic components is listed below.

- Flight Controller - 25g
- R/C Receiver - 25g
- Silver Blade Frame - 150g
- 4 Motors - 250g
- ESC - 10 g
- 3S LiPo Battery (1300-1800 mAh) - 150g
- FPV Camera and Transmitter - 60g
- Others - 10g

(i) What is the function of an ESC? [2 marks]

(ii) Calculate the required thrust of each motor. [4 marks]

(iii) A motor with actual weight of 76 g and force coefficient of 6×10^{-8} N/rpm^2 is selected. How much should each motor rotate for *hovering* action? (Assume gravity acceleration ~ 9.81 m/s^2) [4 marks]

Continued...

Question 4 (25 marks)

(a)

(i) Briefly discuss what is a *social robot.* Give an example of a social robot. [5 marks]

(ii) Collaborative robots, or cobots, are getting popular nowadays because they can safely operate alongside humans in a shared workspace. List down 5 potential applications of cobots in manufacturing industries. [5 marks]

(b) A cobot is mounted on a mobile platform which travels at a speed of 1.2 m/s along the y-axis. The centre of its body starts from position $(x,y) = (0, 0)$. It uses its arm to grab an object centred at position (1 m , 3 m). The maximum arm reach is 1.5 m.

(i) How much grasping time is allowed if the cobot is not to slow down? [4 marks]

(ii) What is the effective arm length (from body center to the object) when $t = 1.8$ s, and $t = 3.5$ s, respectively? [5 marks]

(c) *Roboethics* is a study of ethical issues related to robots, such as whether A.I. robots pose a threat to humans in the long or short run, whether some applications of robots are *ethical* (such as killer robots in war), and how robots should be designed such that they act *ethically*. Briefly discuss what would happen if robots become *significantly smarter* than humans. [6 marks]

End of Page